Investment Strategies in Small Tech

A Decade of Nano-Engineered Materials

Maciek E. Orczyk

Intel Capital

Intel Capital

- Strategic investment arm of Intel Corp founded in 1992.
- Focus on process technology, advanced materials, tools, software, internet and service companies.
- Investment sectors: Computing & Comms, Networking, Digital Home.
- $750M invested in 2003.
- International investments in 25 countries on five continents; increase from 5% (1997) to 40% (2003).
- Four types of investments:

  ① Ecosystem, ② Market development, ③ Gap fillers, ④ Eyes & Ears

- Proposals: intel.capital.proposals@intel.com

VC Environment

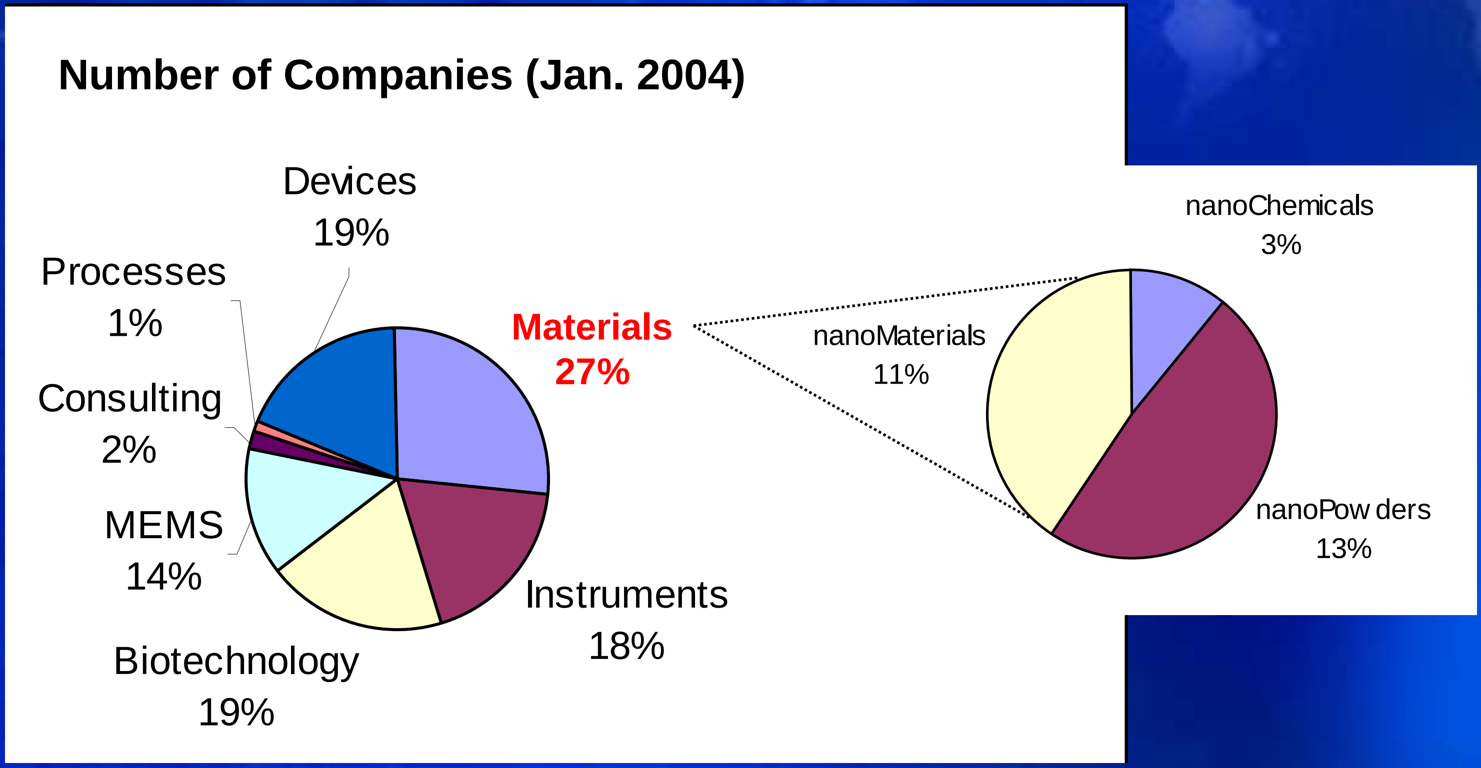
◊

Business Opportunity

◊

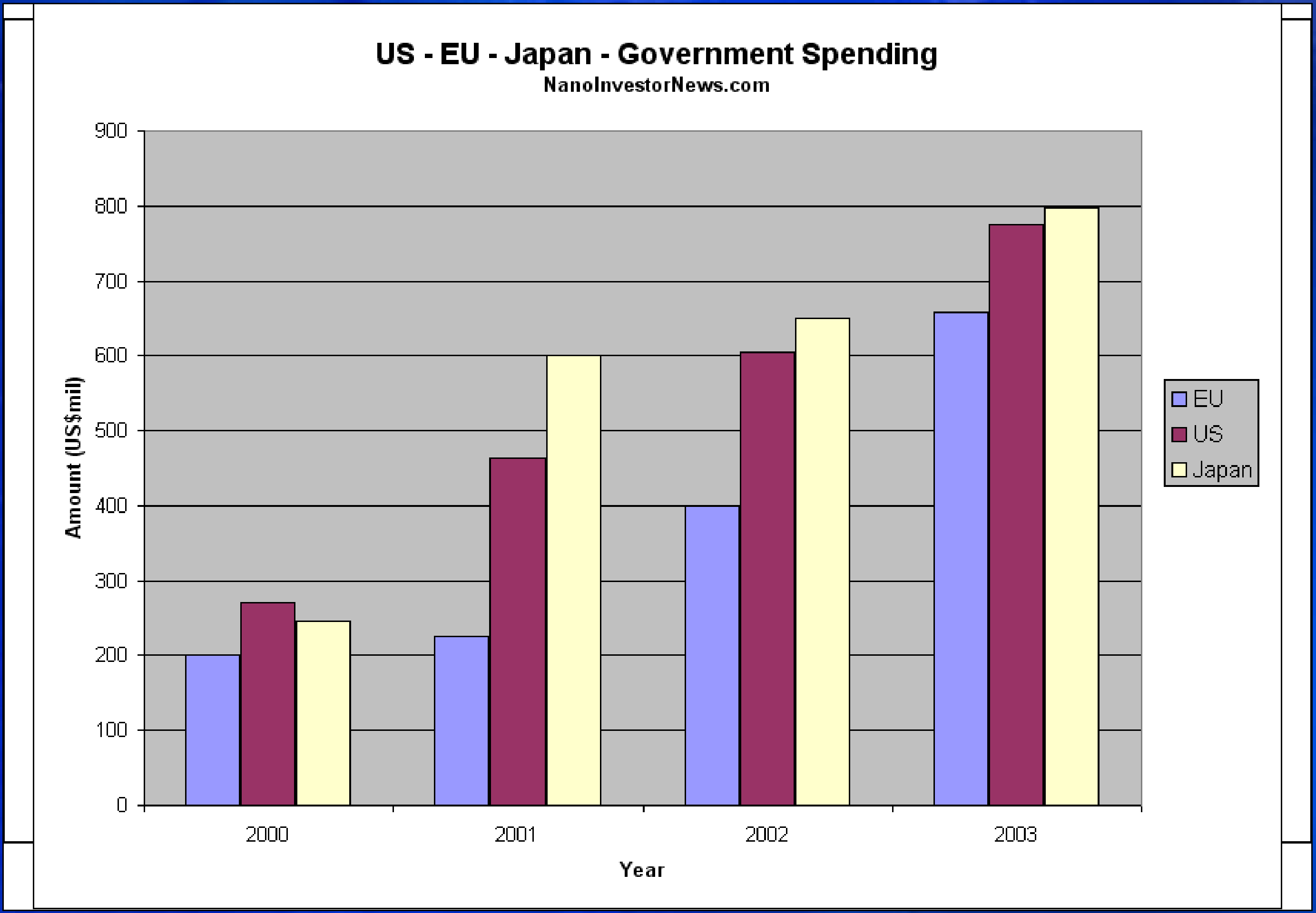
Technology Prospects & Challenges

Nanotechnology Sectors



Source: NanoInvestorNews

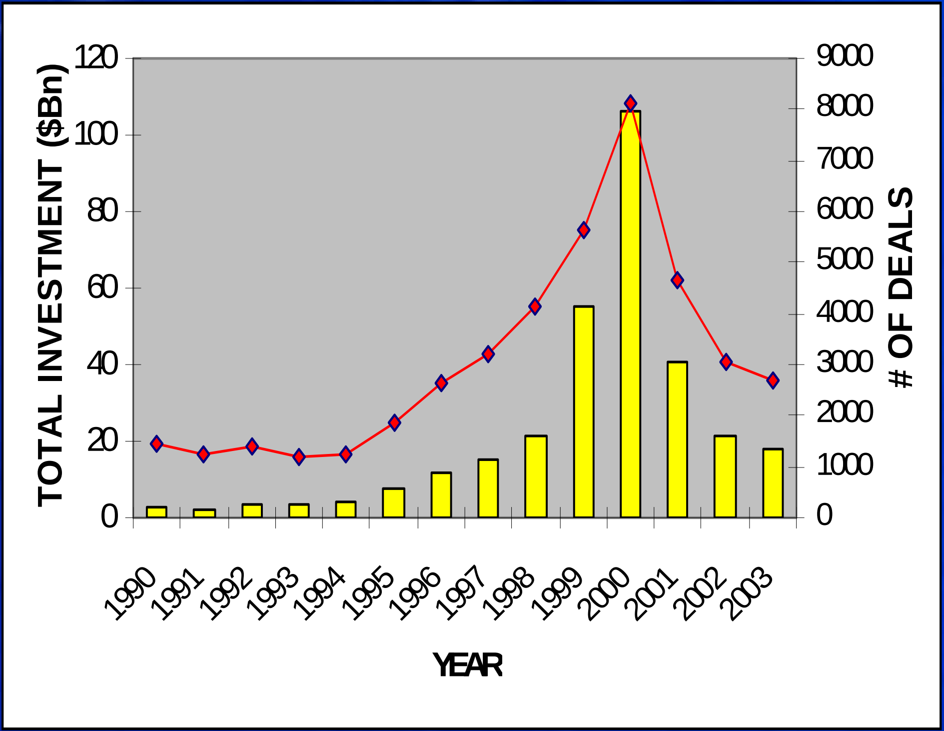
Global Nanotechnology Funding



Source: NanoInvestorNews

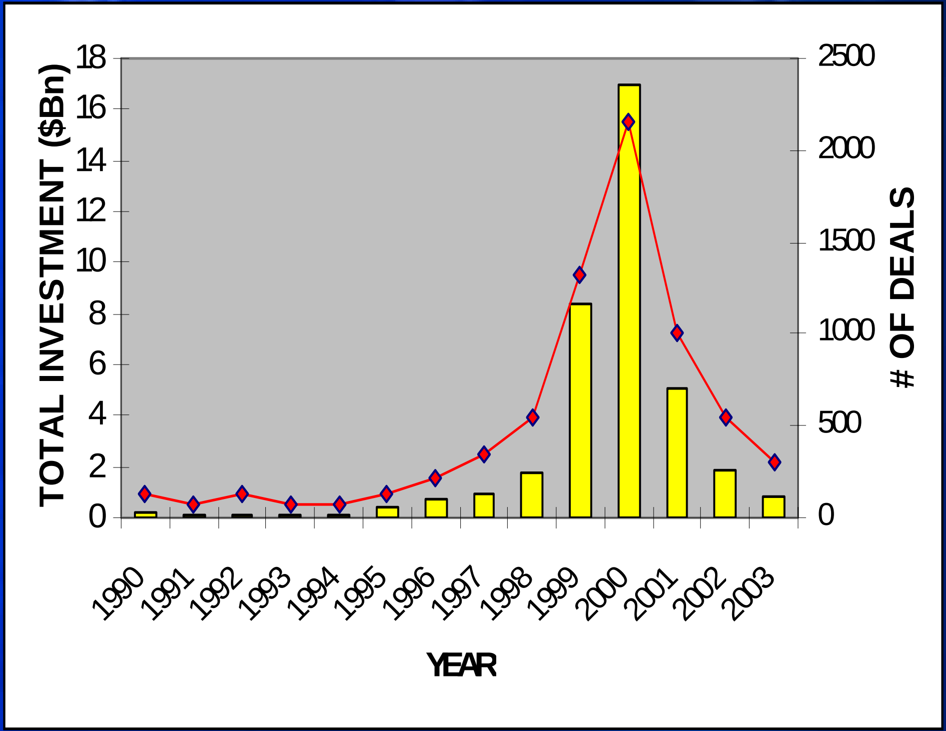
VC Activity

VC Activity by Year



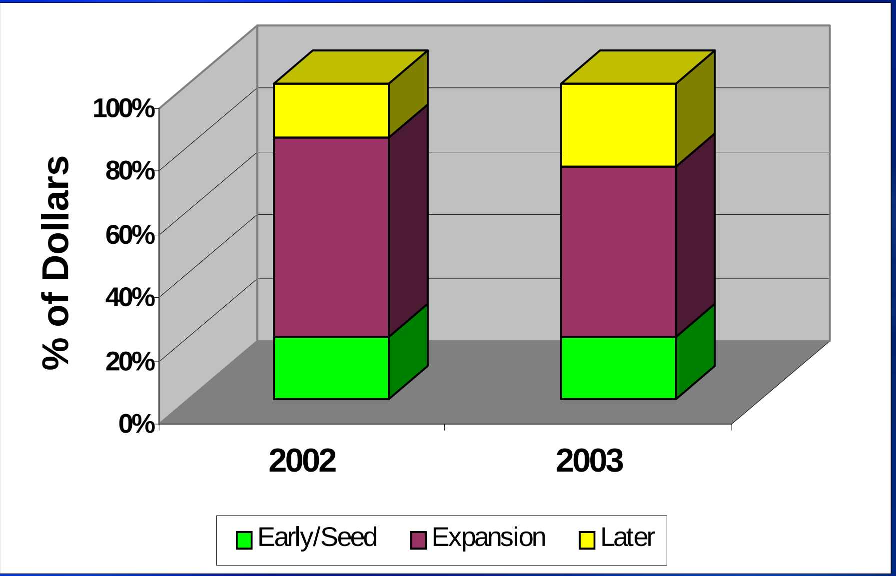
Source: NVCA

Corporate VC Activity by Year



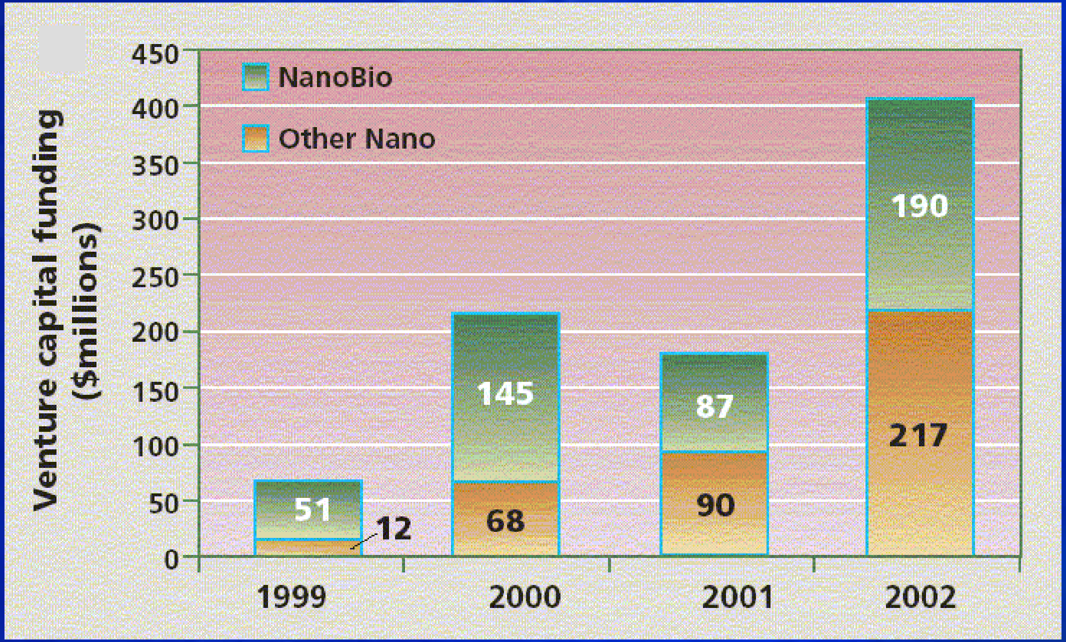
Source: NVCA

Where the money goes...?



Source: NVCA

Source: R. Paull et al., Nature Biotechnology 21 (2003) 1144.



Competitive supply chain in making

Moving into the 3rd Era

from to

[Path to Commercialization]

Credibility
- mgmt team and VCs
- technical/market savvy
- sample data

Market Potential of Product or Service

Competitive Landscape & Biz Model

Funding Plan

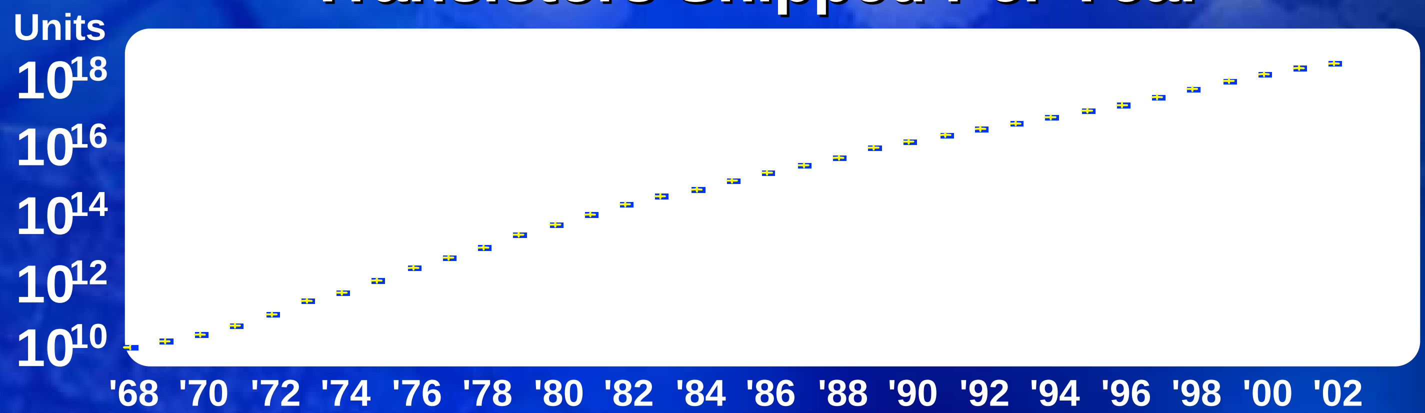
Exit Strategy

Strategic Alignment
- present
- roadmap
- expansion

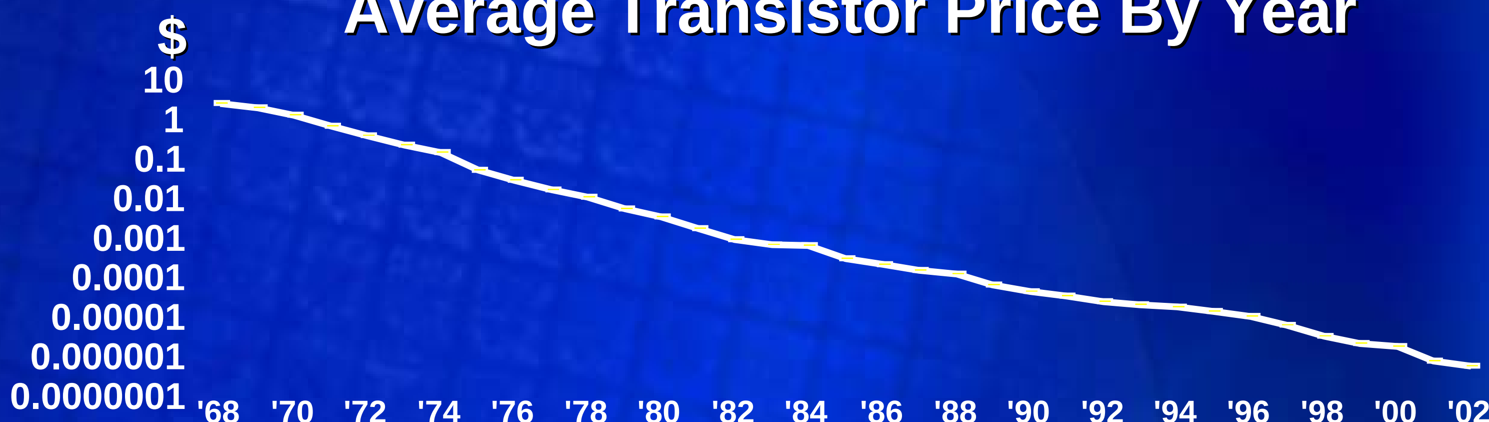
A path to follow...

Moore’s Law in Action

Transistors Shipped Per Year



Average Transistor Price By Year

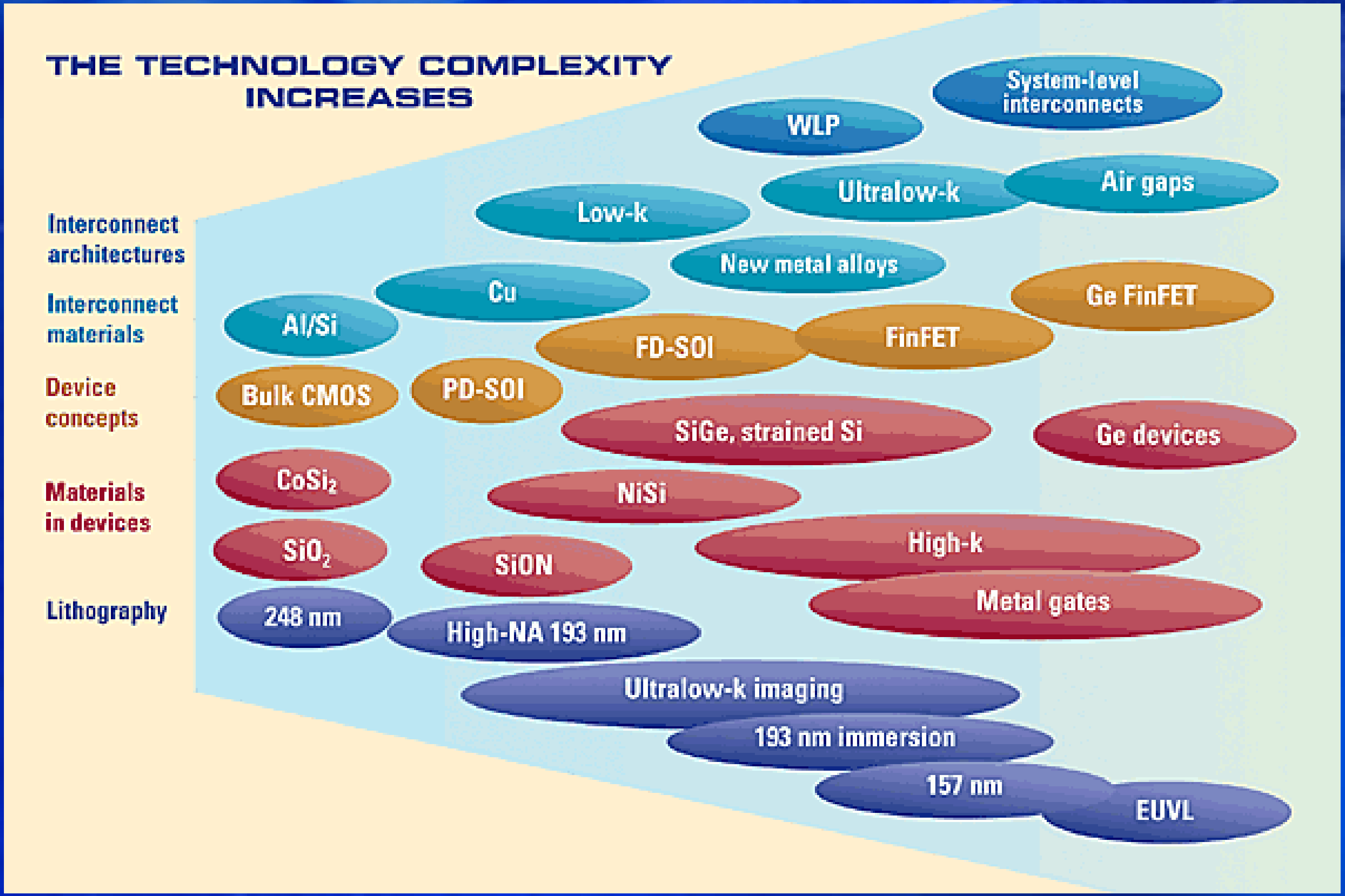


Source: Dataquest, Intel

Moore’s Law is driven by economics

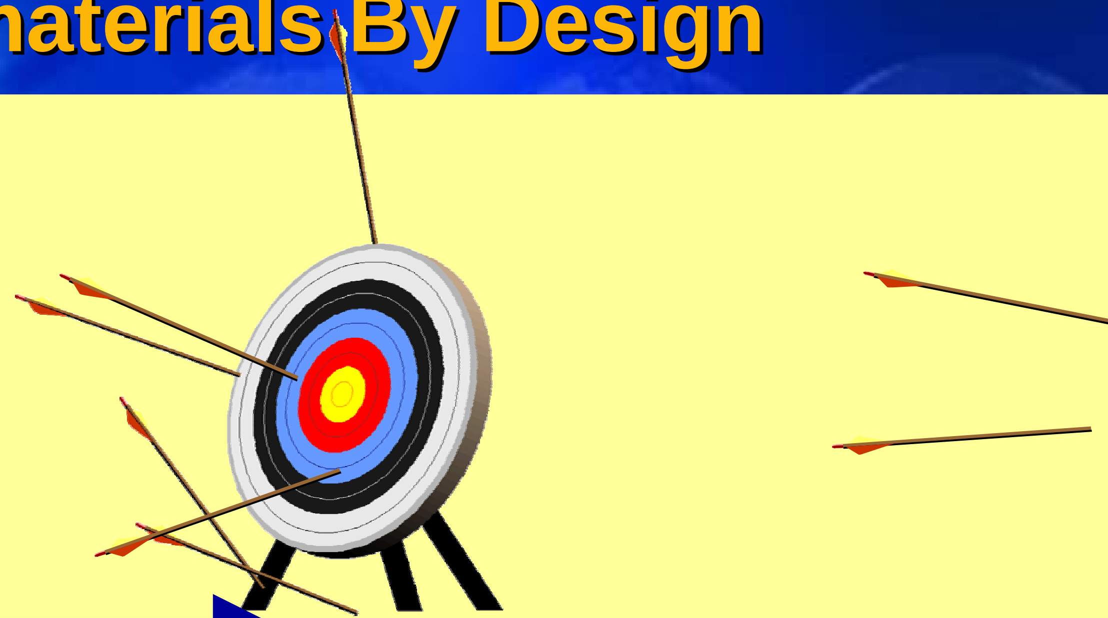
intel

Quest for New Materials



Driving Moore's Law with nano-Engineered Materials

Nanomaterials By Design

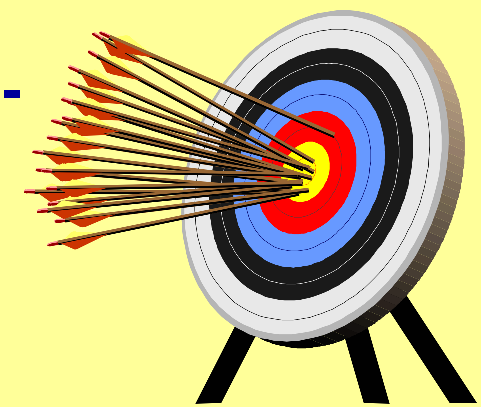


Discovery-based Product Development

Time

Nanomaterials By Design

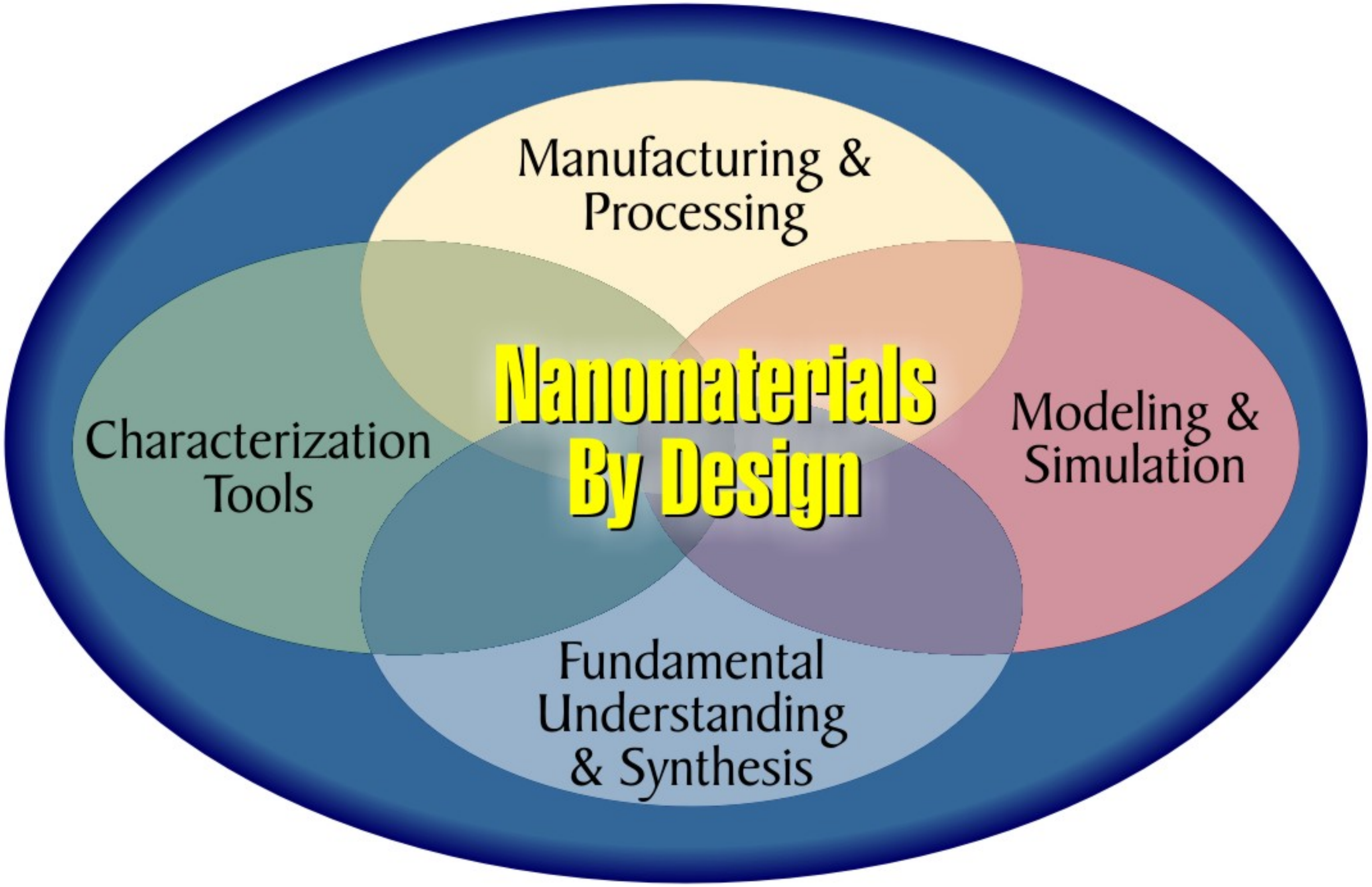
Application-based Problem Solving



Time

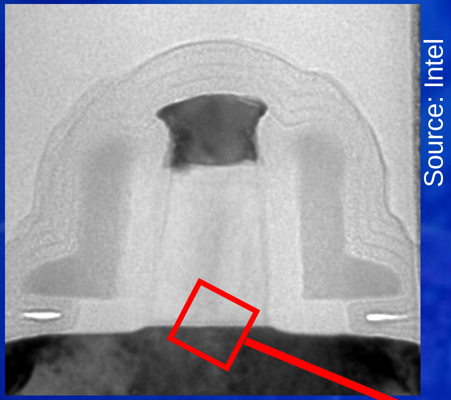
Source: Chemical Industry Vision 2020 Technology Partnership

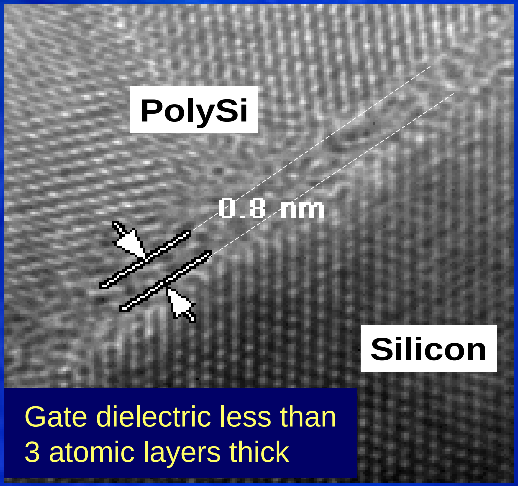
Implementation of Roadmap Strategy: Multidisciplinary, Interdependent, R&D Integrated From Fundamentals to Function



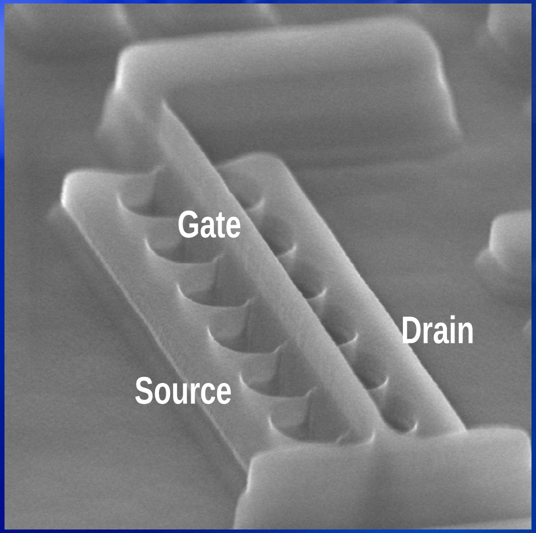
Source: Chemical Industry Vision 2020 Technology Partnership

Transistor Scaling





Source: Intel



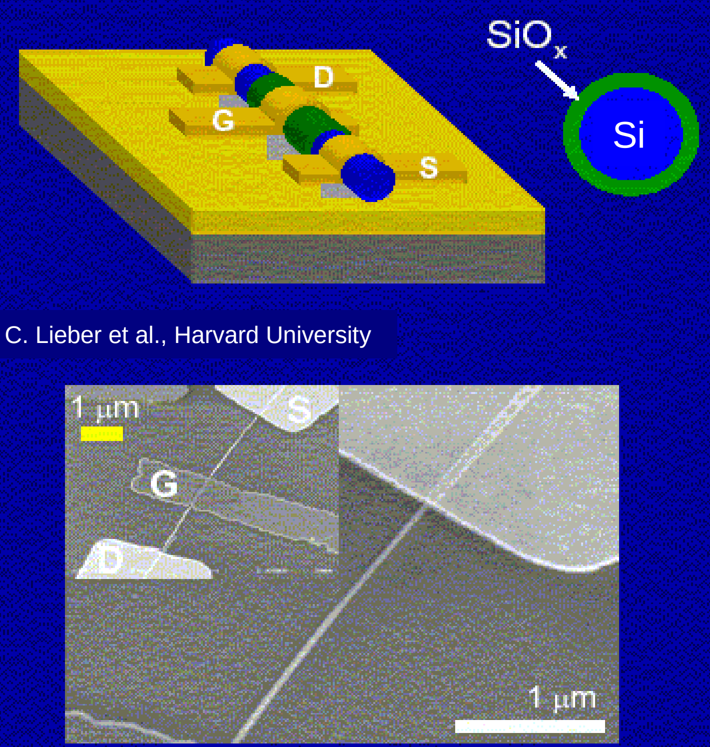
3-D Device Architecture

Future Material Options:

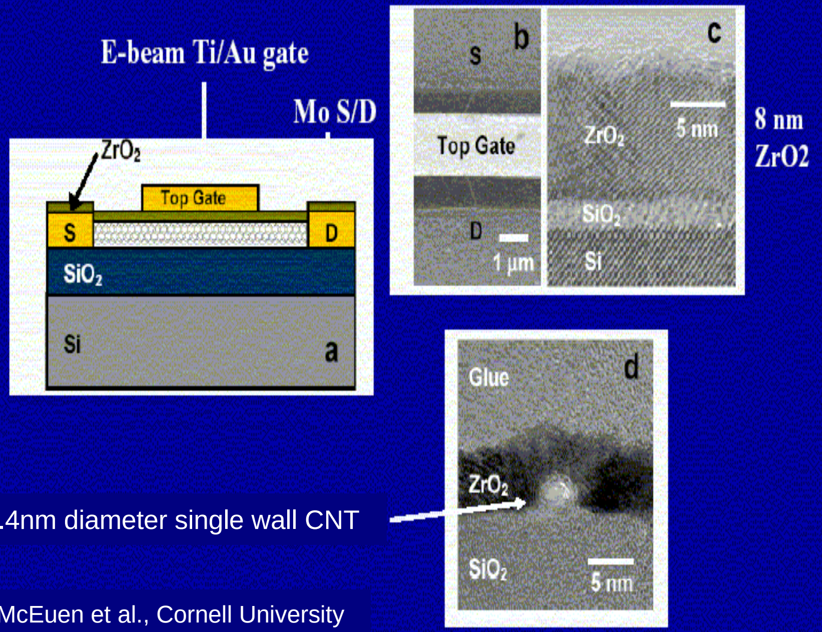
- **strained lattices**
- **high-k gate dielectric (e.g. by ALD)**
- **metal gate**

	SiO2	High-K
Capacitance	1.0x	1.6x
Leakage	1.0x	0.01x

Possible post-CMOS Devices



C. Lieber et al., Harvard University

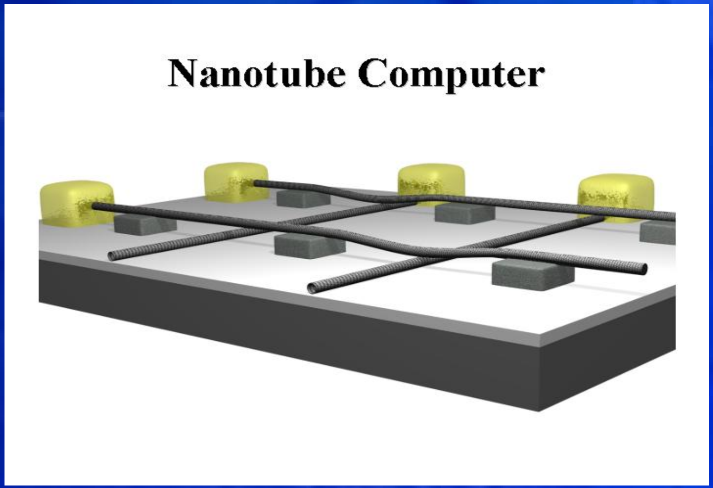


1.4nm diameter single wall CNT

P. McEuen et al., Cornell University

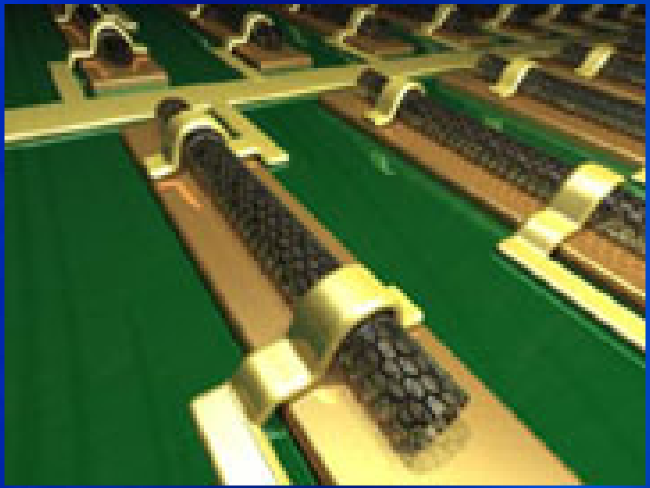
Nano-Materials in Interconnect

Carbon Nanotubes



Source: Nantero Inc.

- Low resistance electrical conductors
- Good mechanical properties
- No electromigration



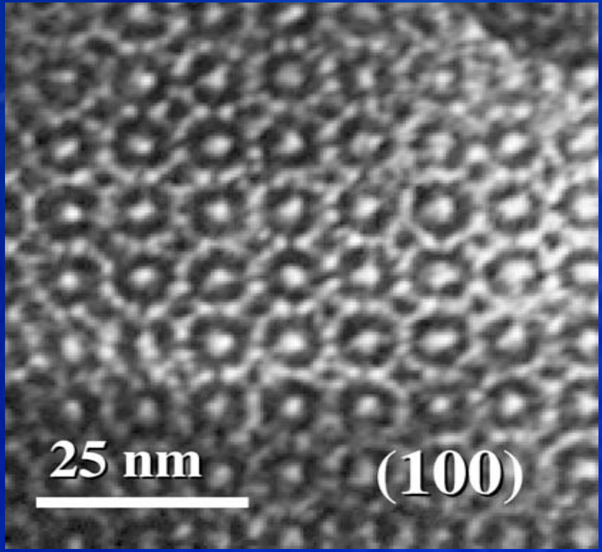
Bachtold et al., Science **294** (2001) 1317

Challenges:

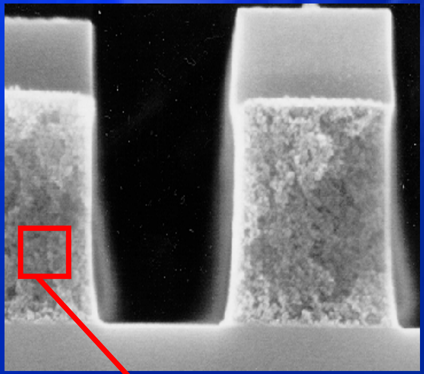
- How to make “long” continuous conductors?
- CNT’s high contact resistance
- How to form high-density conductors?

Nano-Materials in Interconnect

Low K Dielectrics



Source: J. Brinker, UNM/Sandia National Labs

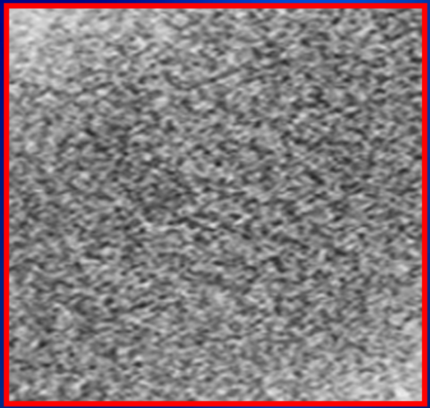


Source: Intel

nano-Engineering in action: Low-k xerogel

- - -

controlled size and connectivity nanopores

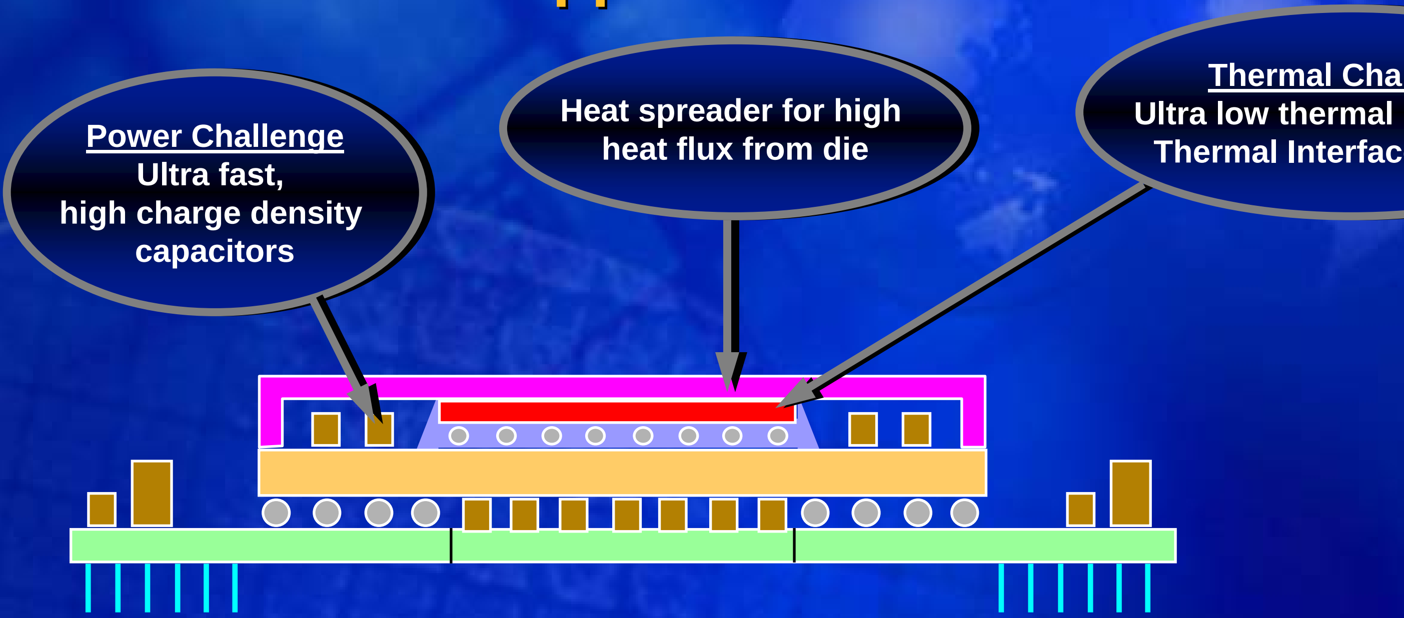


Molecular Self-Assembly

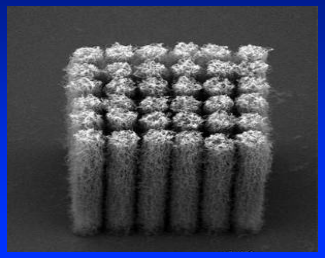
- **Materials of the gel self-organize into a Low K dielectric**
- **Assembly driven by two-sided organic surfactant molecules**

Integrated Thermal & Power Delivery Management

Nano-Materials Opportunities

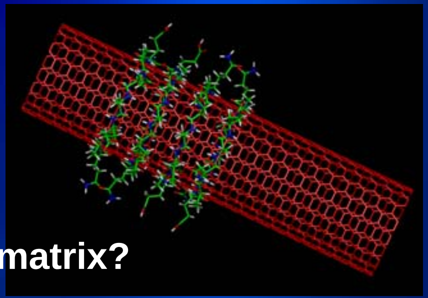


MW Carbon Nanotubes



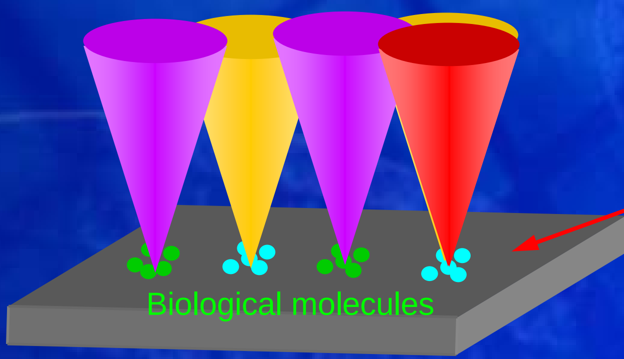
Nano-Materials for Thermal Management:

- CNT thermal conductivity ~5-7X copper
- Challenges
    - Ability to form a “good” thermal contact
    - Ability to pack CNTs in a dense usable form
    - Are thermal properties maintained when functionalized in a polymer matrix?



nano-Bio Materials

Optical excitation and signal

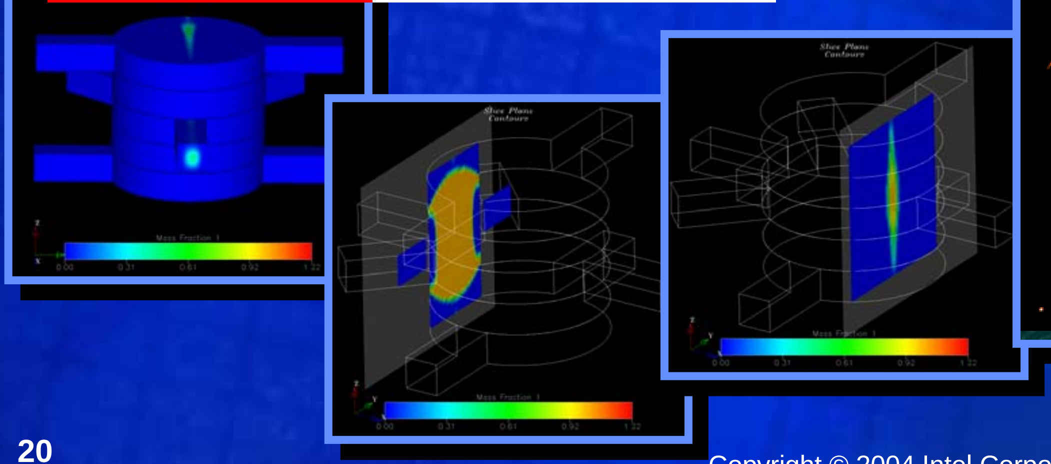


nanoporous SERS substrate

Single DNA molecules
on silicon chip

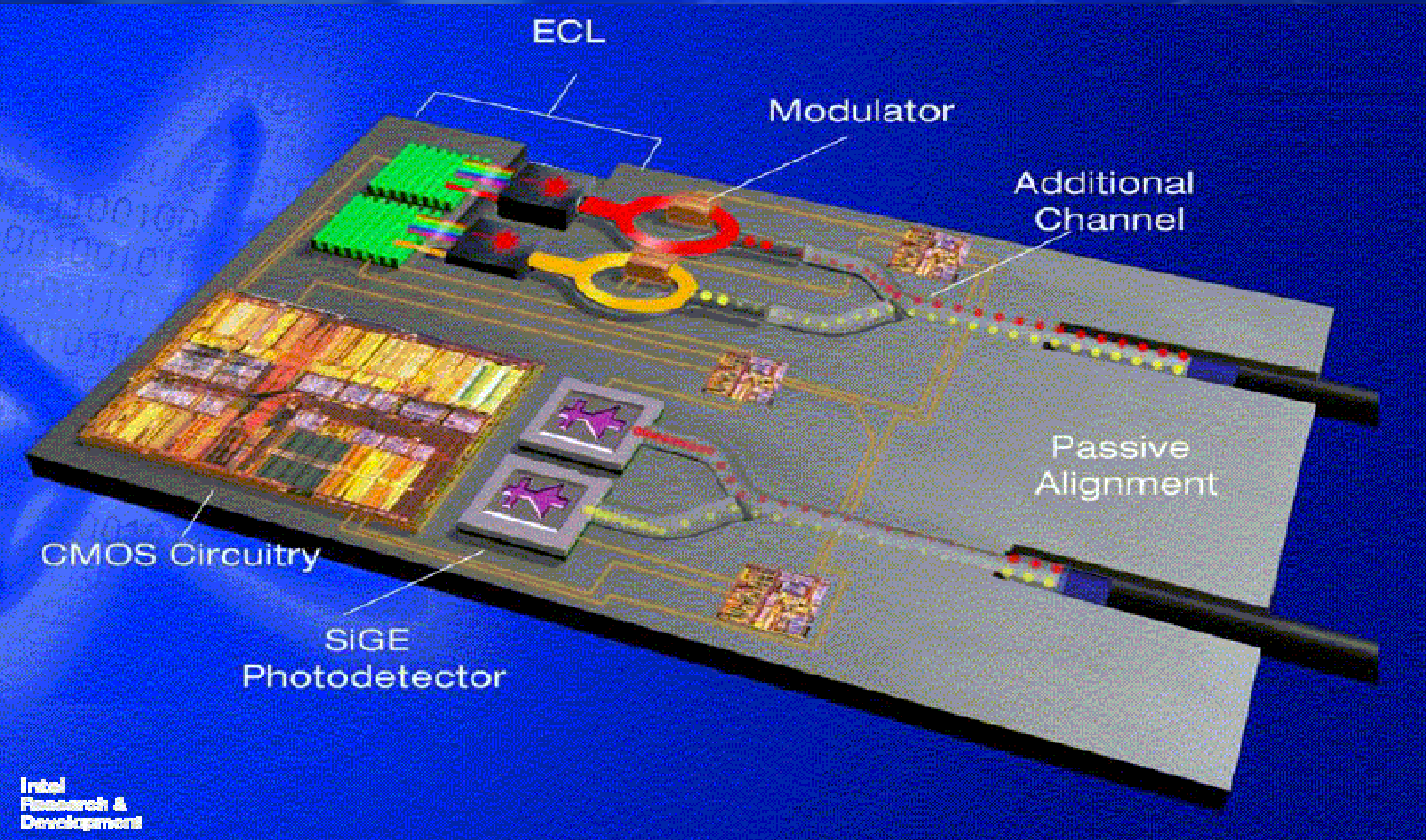
- **ultra sensitive single molecule detection**
- **protein detection**
- **biological and chemical sensors**

3-D Nanofluidic Molecule Positioner



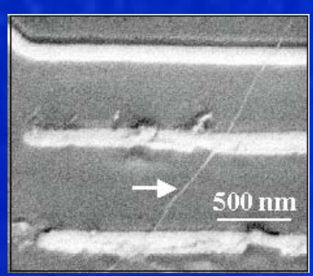
Source: Intel Precision Biology

Silicon Photonics

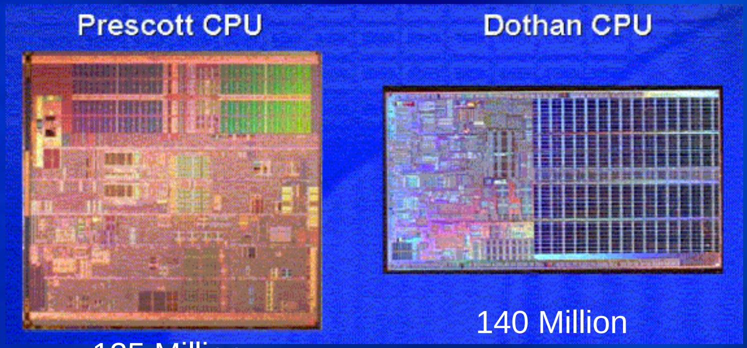


Summary

- Moore's Law drives convergence of Computing, Communications and Consumer Electronics on silicon.
- Silicon nanotechnology is production reality and follows Moore's Law.
- Companies developing nanoengineered materials will play important role in extending Moore's Law into the future.
- Progress needed in controlled assembly, purity, cost, EHS, and ...
- Large-scale integration.



?



125 Million Transistors

140 Million Transistors